Density and Measurements

Goals

1. To become familiar with chemistry lab equipment.
2. To measure and record length, volume and mass accurately with the correct number of significant figures.
3. To use significant figures correctly in calculations.

Making Measurements

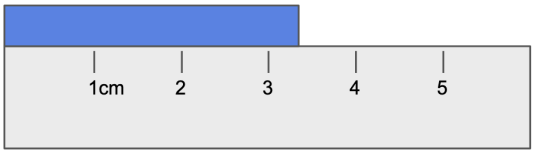
Measurements are central to science and medicine. Scientists and medical professionals need to read and report measurements accurately and precisely to convey information to others. In this lab you will learn how to read scientific instruments and report the results with the correct number of significant figures. Measurements contain certain and uncertain digits. The final digit of a measurement is assumed to have uncertainty and is usually estimated from the instrument being read. You will be expected to carefully and correctly record measurements using the procedures below for the rest of the course.

Units of Length

We will use rulers to measure length. The standard unit of length in the metric system is the meter (m). A meter is divided into 100 centimeters (cm). Each centimeter is divided into 10 millimeters (mm). Measurements taken with instruments with a scale, such as rulers, should be recorded to the one place past the smallest division.

Smallest division on the ruler: 1 cm (ones place)

Estimate to the nearest: 0.1 cm (tenths place)



A correct reading of this instrument could be **3.3 cm**.

Units of Volume

Volume is a derived unit based on length. The unit of basic metric unit of volume is the liter (L). There are 1000 mL in 1 L. A milliliter is the same volume as 1 cm^3. We will use several types of instruments to measure volume in chemistry class.

	**BEAKER** Straight sides, wide opening	• used to hold, mix and heat liquids	• markings give an approximate volume • *beakers are not used for careful volume measurements*
	**ERLENMEYER FLASK** Tapered sides, narrow opening	• used to hold, mix and heat liquids • the shape is useful for swirling liquids without spilling and for limiting evaporation	• markings give an approximate volume • *erlenmeyers are not used for careful volume measurements*
	**GRADUATED CYLINDER** Straight sides, narrow opening	• used to accurately measure volume • **NOT** used for heating or mixing	• use the smallest size that accommodates the volume • read at eye level • read the scale increasing up if two scales are shown • read lowest part of the curved surface (the meniscus)

	**BURET** Straight, narrow sides, stopcock at bottom releases liquid	• used to measure the volume of liquid dispensed • primarily for titrations	• read the <u>volume that has been dispensed</u>, not the volume that buret still contains • read at eye level • read the bottom of the meniscus

Buret reading

Smallest division on the buret: 0.1 mL (tenths place)

Estimate to the nearest 0.01 mL (hundredths place)

A correct reading of the volume dispensed could be **<u>15.45 mL.</u>**

Units of Mass

A laboratory balance is used to measure mass. Mass is the measure of the amount of matter. The metric unit for mass is the gram (g) while the SI unit of mass is kilogram (kg). The balance has a metal pan to weigh materials on. Around the pan, there is a plastic shield and a cover. These protect the balance from fluctuations caused by drafts.

<u>Using a balance</u>

- Press the button labeled "tare" or "zero" until the numbers stabilize at zero.
- If massing a chemical, place a weigh boat on the balance before zeroing. <u>Never put chemicals directly on the balance.</u>
- Place the material on the pan, or scoop into the weigh boat with a spatula.
- If the last digit fluctuates, you may estimate its value.
- <u>*Write every digit on the balance on your data sheet - never round off a mass measurement*</u>. The final digit is considered uncertain.
- Weigh boats are single use. Dispose of them once used.
- Only weigh objects that are at room temperature.

weigh boats

Procedures will often say "accurately weigh about 5g of X", this means that you do need exactly 5.000 grams, but whatever mass you portion out should be recorded accurately. For instance 5.080 g and 4.952 g might be recorded as an accurate mass of approximately 5 g. Trying to hit exactly 5.000 g is unnecessary and a waste of time.

Laboratory Activity

<u>Materials that you will need to collect:</u>

1 metal block	beaker (50 mL)	10 mL graduated cylinder	isopropyl alcohol
Deionized water	ruler		

Procedure

A. Measuring Volume (read the lab manual before you start this!!)

1. Find the class set of instruments at the front of the room.
2. Carefully examine the scale of each instrument to determine the volume increase of the smallest marks. The estimated digit will be one place beyond the marks.
3. In the right column, write the volume of water to the correct number of decimals/places based on the instruments markings.

B. Determining the Density of Water

1. Get a different **10 mL** graduated cylinder for your group. Record the mass of the graduated cylinder. Always record **all digits** on the balance.
2. Fill the cylinder roughly 2/3 full with deionized water and record the mass. *The amount of water is not important – do not try to fill exactly to a line!*
3. Read the volume of the water to the correct number of places. Use volume and mass to calculate the density of water.
4. Find the percent error from the actual density of water (1.00 g/mL) for your measurement.

$$Percent\ Error = \frac{|actual\ value - your\ experimental\ value|}{actual\ value}\ x\ 100\%$$

5. Get a 50 mL beaker for your group. Weigh it and record the mass..
6. Fill the beaker roughly 2/3 full with deionized water and record the mass. *The amount of water is not important – do not fill exactly to a line!*
7. Read the volume of the water to the correct number of places. Use volume and mass to calculate the density of water.
8. Find the percent error from the actual density of water (1.00 g/mL) for your measurement.

C. Determining the density of isopropyl alcohol

1. Obtain, wash and carefully dry a 10.0 mL graduated cylinder and weigh it. Record the mass to the correct number of significant figures.
2. Fill the cylinder to at least 2/3 full with isopropyl alcohol and reweigh. Record the mass. *The amount of isopropyl alcohol is not important – do not try to fill exactly to a line!*
3. Read the volume of the isopropyl alcohol to the correct number of significant figures. Use volume and mass to calculate the density of isopropyl alcohol. This will be your experimental value.
4. Look up the density of 99% pure isopropyl alcohol (actual value) and calculate the percent error.

$$Percent\ Error = \frac{|actual\ value - your\ experimental\ value|}{actual\ value}\ x\ 100\%$$

5. **Pour the used isopropyl alcohol back into the original container.**

D. Determining the Density of a Metal Block

1. Obtain a metal block, measure its mass using an analytical balance.
2. Obtain a ruler that has a **centimeter** scale. Record the length (*l*), width (*w*) and height (*h*) of your metal block to the correct number of significant figures.
3. Calculate the volume in cm^3 of the metal block. V = *l* • *w* • *h.*
4. Calculate the density of the block in g/cm^3 to the correct number of significant figures using your data for volume and density. Density = mass / volume
5. Determine the likely identity of the metal block based on the density table shown.

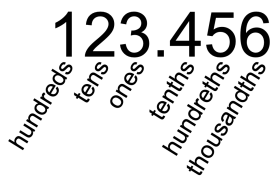
Metal	Density (g/cm^3)
Aluminum	2.70
Brass	8.74
Copper	8.96
Iron	7.86
Lead	11.4
Tin	7.31
Zinc	7.13

CHM111 Lab - Density and Measurements – Grading Rubric

Criteria	Points
Worked actively in the lab group of 3 or fewer students. Did parts of the experiment. (Just writing down data is not doing part of the experiment!)	3
Part A: Volume measured correctly based on the instrument scale.	4
Part B: Measurements recorded with the correct digits and units	2
Part B. Calculations are correct; work is shown in detail with units and correct significant figures.	2
Part C: Measurements recorded with the correct digits and units Calculations are correct; work is shown in detail with units and correct significant figures.	3
Part D: Measurements recorded with the correct digits and units Calculations are correct; work is shown in detail with units and correct significant figures.	4
Post Lab: Question 6. Uses indicated conversions. Calculations are correct; work is shown in detail with units and correct significant figures.	2
Total	20

Density Lab Name _____ Team Name: _____

<u>Remember to include the proper units</u> for all measurements and <u>show all your work</u> for all calculations. Round <u>calculations</u> according to sig fig rules. Measurements are not rounded.



A. Measuring Volume

Glassware	**Mark Increments** What place do the smallest marks go to? (ones, tenths, hundredths, etc)	**Estimated Digit** What place should be estimated?	**Measurement.** Record the volume of water to the correct place.
10 mL graduated cylinder			
100 mL graduated cylinder			
50 mL Beaker			
Buret			

B. <u>Measuring the density of water.</u>

Graduated cylinder	Measurement (don't forget your units and sig figs!)
Mass of graduated cylinder	
Mass of cylinder with water	
Mass of water	
Volume of water (read to correct place - see part A)	

1 a)Calculate the density of water using the graduated cylinder. Show all of your work with units and round for SF.

b) Calculate the percent error. Show your work.

Beaker	Measurement (don't forget your units and sig figs!)
Mass of empty beaker	
Mass of beaker with water	
Mass of water	
Volume of water (read to correct place - see part A)	

2 a)Calculate the density of water using Beaker. Show all of your work with units and round for SF.

b) Calculate the percent error. Show your work.

3. Which piece of glassware is better for accurately measuring volume and why? Use CER format in your answer:
Claim - State which piece of glassware is more accurate
Evidence - state specific evidence that supports your claim (density % error)
Reasoning - explain why the evidence supports your claim

C. Determining the Density of Isopropyl Alcohol

	Remember your units
Mass of empty cylinder	
Mass of cylinder with isopropyl alcohol	
Mass of isopropyl alcohol	
Volume of isopropyl alcohol (use correct sig fig reading as in part A)	

4a)Calculate the density of isopropyl alcohol based on your measurements. Show all of your work and use your units.

b) Look up the density of 99% pure isopropyl alcohol and Calculate percent error.

D. Determining the Density of a Metal Block

Mass of metal block	
Ruler mark increments What place do the smallest marks go to?(ones, tenths, etc)	
Estimated Digit What place should be estimated?	
Length of block	
Width of block	
Height of block	

5a) Calculate the volume of the metal block in **cm^3.** (Show work, include units and correct number of sig figs.)

b) Calculate the density of the metal block. (Show work, include units and correct number of sig figs.)

c). Based on the table in the lab instructions, what metal is your block? _____

6. Find the mass in **kilograms** of 1.65 ft^3 of your metal based on the experimental density (your answer in 5b). Show all work in detail with units and correct sig figs. Use metric prefix conversions and modifications of 1 ft = 12in*, 1 in = 2.54 cm* in your answer.